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ABSTRACT

University students were administered three Piagetian tasks and a spatial relations test, the Revised Minnesota Paper Form Board. Students' American College Test (ACT) mathematics scores were also recorded. A measure of conservation of weight, administered individually, was the first Piagetian task. Two paper and pencil tests of progressively higher Piagetian functioning, the Concrete-Operational Reasoning Test and the Logical Reasoning Test were also administered. A path analysis was performed on the five measured variables, using a set of recursive models and with the following ordering: (1) Conservation of weight; (2) Concrete-Operational Reasoning Test; (3) Logical Reasoning Test; (4) Spatial relations; and (5) ACT mathematics. Two paths were dropped as being too small to be of explanatory value: the path from conservation of weight to ACT mathematics, and the path from conservation of weight to Concrete - Operational Reasoning Test. The data was also analyzed in a two way analysis of variance by age and sex on all variables but the ACT mathematics. Males scored significantly higher on the Logical Reasoning Test. Although non-significant, the females scored somewhat higher on spatial relations than did the males; this outcome is in direct opposition to most published findings. (Author/RD)

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STAGES OF PIAGETIAN TASKS AND SPATIAL RELATIONS IN UNIVERSITY STUDENTS

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Most Piagetian oriented research has centered on younger children; those studies done on older subjects tend to emphasize lower level cognitive functioning rather than formal operations. At least part of the reason for lack of research on formal operations is due to the lack of usable tasks to measure higher level functioning in a Piagetian perspective. One exception to this paucity of research was a study by Williams, Clark and Brekke (1977). They investigated four Piagetian tasks and their relationship to American College Tests (ACT) scores. Of particular interest in this study was the phenomenon of high ACT scores on all Piagetian tasks except conservation of weight. Additionally, the relationship of Piagetian tasks to spatial relations seems also to be an area that has been relatively uninvestigated despite Piaget's own interest in spatial functioning of children (Piaget, Inhelder and Szminska, 1960).

Subjects and Procedures

The subjects were students in a Midwestern middle-sized university (N = 100); 27 males and 73 females were included. The age range was 17 years, 9 months to 41 years, 8 months, with a mean of 21 years, 3 months; students were volunteers from undergraduate courses in educational psychology.

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Three different Piagetian tasks were administered: conservation of weight, the Concrete-Operational Reasoning Test (Ankney and Joyce, 1974) and the Logical Reasoning Test (Burney, 1974).

The conservation of weight tasks in the study were modifications of the series of thirteen steps formulated by Furth (1964) in his investigation of the thinking processes of deaf children.

The Concrete-Operational Reasoning Test is a paper and pencil test designed to examine functioning at the concrete-operational level. A fair assessment of the test might place it nearer the upper end of the concrete-operational stage (7 - 11 years). Children at this age level would probably perceive the test as being of some difficulty. The test includes 30 items.

The Logical Reasoning Test is a 21 item multiple choice item, that while it was formulated to test for the acquisition of the formal-operations stage (normally occurring at 11-14), clearly is a challenging test for high school students. There are several items that might be seen as measures of elementary physics; several syllogystic reasoning items are included, as well as some reasonably complex verbal analogies.

Spatial relations were measured by the Revised Minnesota Paper Form Board Test (RMPFB) Form A (Likert and Quasha, 1970). The RMPFB is a 20 minute speeded test consisting of 64 two-dimensional diagrams cut into separate parts. Five alternative sets of figures are given with one of the sets corresponding to the figures that make up the original diagram. The test measures those aspects of mechanical ability requiring the capacity to visualize and manipulate objects in space.

Finally, the mathematics scores for the American College Tests (ACT)

were available on 79 of the 100 subjects. These scores were available through the regular testing program for admission to the university; not all students uniformly take identically the same tests for admission, though the ACT test is highly recommended due to its perceived use in counseling students.

The present study is the third of three studies patterned after Williams, Clark and Brekke (1977). The other two studies used an identical procedure to the present study with the exception that ACT test scores were not available; one study used junior high aged students (Brekke and Williams, 1978) while the other study used high school students (Williams and Brekke, in press, a).

Results

Figure 1 exhibits the path diagram for the three Piagetian variables, spatial relations and the ACT mathematics test scores; the path diagram was constructed on the group that had scores available on all five variables.

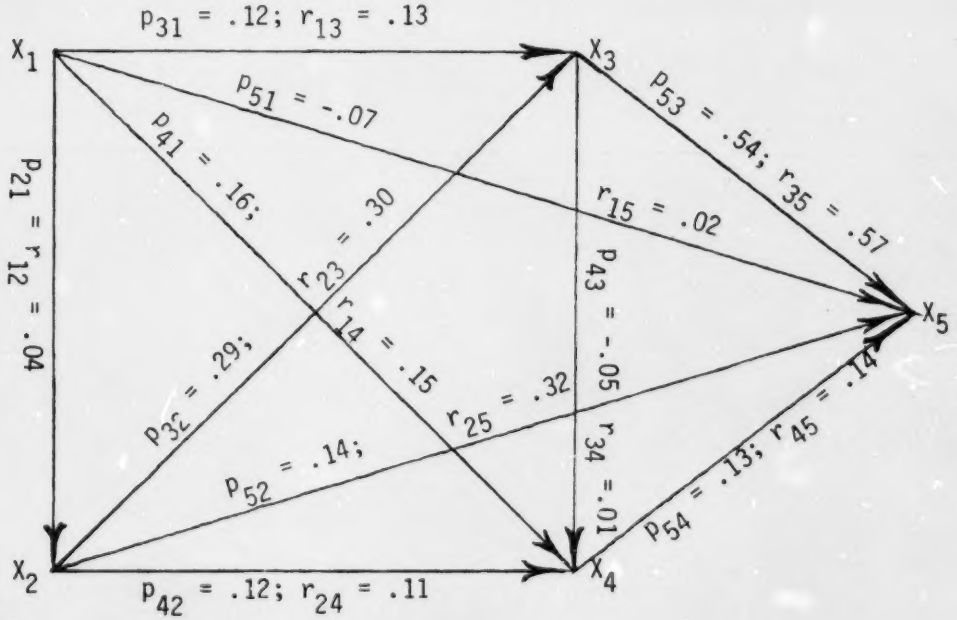

Figure 1 Legend: X_1 = conservation; X_2 = Concrete-Operational Reasoning Test; X_3 = Logical Reasoning Test; X_4 = spatial relations and X_5 = ACT Mathematics.

Both p_{21} and p_{51} can be dismissed as significant paths; in fact, several other paths miss significance but are retained due to their logical consistency. Clearly the strongest path is from the Logical Reasoning Test to the ACT Mathematics score. The path from the Concrete-Operational - Reasoning Test to the Logical Reasoning Test is also reasonably high ($p_{32} = .29$).

The second part of the analysis regarded a two-way classification for sex and age on each of the five criteria; because of disproportionality, the regression solution given in Williams (1977) was used. Means for the two-way cross-classification are shown in Table 1. Males score significantly higher ($p < .05$) than females on the Logical Reasoning Test. Perhaps even more interesting, though non-significant, is the tendency for females to score higher on spatial relations. Most studies reporting spatial relations (including the RMPFB) show males scoring higher.

TABLE 1

Means by Age and Sex for Three Piagetian Tasks and Spatial Relations for University Students (N = 100)

Conservation

	18 years	19 years	20 years	21-24 years	Over 25 years	
Male	.778	.750	1.000	.889	1.000	.830
Female	.960	.786	.941	.800	1.000	.904
	.912	.770	.947	.842	1.000	

Concrete-Operational Reasoning Test

	18 years	19 years	20 years	21-24 years	Over 25 years	
Male	25.44	24.75	25.00	25.44	26.00	24.81
Female	24.04	25.14	25.29	25.10	25.29	25.37
	24.41	25.06	25.26	25.26	25.50	

Logical Reasoning Test

	18 years	19 years	20 years	21-24 years	Over 25 years	
Male	17.33	18.25	13.50	15.67	17.00	16.59
Female	14.80	14.71	15.76	14.60	13.00	14.81
	15.47	15.40	15.39	15.39	14.20	

Spatial Relations (RMPFB)

	18 years	19 years	20 years	21-24 years	Over 25 years	
Male	41.56	47.50	45.50	45.89	39.00	43.89
Female	45.28	48.21	45.00	45.80	42.00	45.53
	44.29	48.06	45.06	45.84	41.10	

Relationships to the Previous Studies

Probably the most unusual aspect of Figure 1 regards the relationship of the Logical Reasoning Test and spatial relations; $r_{34} = .01$, $p_{43} = -.05$. Not only is this outcome unexpected, it is considerably different from junior high students ($r_{34} = .50$, $p_{43} = .37$) and high school students ($r_{34} = .44$, $p_{43} = .30$). When comparing the means of the three groups of subjects, the university students score higher on the Piagetian tasks but intermediate between the junior high and high school students on the spatial relations test. Why this would be so is not entirely clear; the university students were volunteers from educational psychology classes and should be fairly representative of such classes. Perhaps students who might do well on tests of spatial relations (such as engineering majors) were underrepresented in the volunteers, but one might still expect the remaining group of university students to perform as well as high school students. A careful rechecking of the data did not reveal any coding errors.

The relationships of spatial relations to the other two Piagetian tasks are different in the university students and the other two groups are different as well. The relationship of the Concrete-Operational Reasoning Test to spatial relations is lower in university students, but higher for the relationship of conservation to spatial relations. Apparently the measure of spatial relations is tapping different types of cognitive functioning in the university students than in the junior high school and high school students.

In an earlier study, Williams, Clark and Brekke (1977) conjectured

that handedness might be related to the possibility of level skipping; that is, it was conjectured that left-handed subjects might score lower on any or all the scales except logical reasoning. The results of three present studies are reported in Williams and Brekke (in press b); no support for the conjecture regarding handedness is given by the total collection of data.

One remarkable outcome was the lack of cognitive differences over fairly large age ranges. For example, the 15 year old high school students did overall at least as well as other high school students and lower than the university students only on the logical reasoning test and the concrete-operational reasoning test; they performed better than any other group on the spatial relations test. One possibility suggested by the data on all three groups is that cognitive differences do not follow a simple age grid from lowest to highest; perhaps age mixing within a larger range than presently occurs would be feasible. While social reasons may intervene, cognitive functioning would not serve as a sufficient reason for age grading courses such as mathematics.

The Criterion Problem - Are the Present Measures Sufficient to Measure their Constructs?

A question that can always be raised is, "Do your tests measure what they purport to measure?" Clearly, most scales in a psychometric vein can rarely do better than, "Well, it's not too bad." Recently Gray, Dewitz and Hofmann (1978) have made a strong statement against any presently available tests to measure formal operations. Similar points could be made against the Concrete-Operational Reasoning Test. At best,

these tests would represent state of the art attempts to measure their constructs. It can be argued that spatial relations as measured by the RMPFB is somewhat different from spatial relations as envisioned by Piaget. There is no compelling reason to attempt to refute these criticisms, insofar as they are intended to be constructive. If, on the other hand, the intent of the criticism is to ignore research using present state of the art measures, then an impasse has been reached.

Before any conclusive statements are made, it is well to review the history of the development of intelligence testing. For several related and unrelated reasons, intelligence testing has been pursued more extensively in regard to its psychometric aspects than any other construct. One might expect that a fairly respectable and respected set of instruments might have evolved from seventy years of trying out the different forms. That we are probably further from a consensus on measuring the concept of intelligence in 1979 than we were in, say 1955, is perhaps one of the few things regarding intelligence testing that has a consensus.

One might conjecture that as Piagetian concepts become more widespread - as attempts at measuring Piagetian concepts increase - that arguments similar to those raised regarding intelligence testing will be raised regarding Piagetian testing. However, the probability of criticism is not sufficient to call for a moratorium on testing Piagetian concepts, although the criticism might be useful in achieving better measures.

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